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DEPARTMENT OF COMMERCE

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MINING METHODS AT THE BLOCK P MINE OF THE ST. JOSEPH LEAD CO., HUGHESVILLE, MONT.

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WM. O. VANDERBURG

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MINING METHODS AT THE BLOCK P MINE OF THE ST. JOSEPH LEAD CO., HUGHESVILLE, MONT.[1]

By Wm. O. Vanderburg[2]

INTRODUCTION

This paper describing the mining practices at the Block P mine of the St. Joseph Lead Co. at Hughesville, Mont., is one of a series of similar papers being prepared by the Bureau of Mines on mining practices, methods, and costs in the various mines of the United States.

ACKNOWLEDGMENTS

In the preparation of this paper the writer acknowledges the assistance of R. H. Willcomb, general manager, William Thorson, mine superintendent, and B. P. Bellport, mining engineer, of the Hughesville division of the St. Joseph Lead Co.; and of E. D. Gardner, supervising engineer, U. S. Bureau of Mines, Southwest Experiment Station, Tucson, Ariz.

GENERAL DESCRIPTION

The Block P mine is in Judith Basin County, Mont., in the Little Belt Mountains, 66 miles by automobile road southeast of Great Falls. The mine is on the north slope of Barker Canyon, at a point where the altitude of the shaft collar is 5,985 feet above sea level. The district is known as the Unorganized Barker Mining District. It is accessible by automobile stage from Great Falls, which city is the nearest general supply center. A company-owned standard-gage railroad 10.8 miles in length, constructed in 1928, connects the mill which is about 2 miles below the mine with the Neihart branch of the Great Northern Railway at Monarch.

The region immediately surrounding the mine is forested with red fir and lodge pole pine, typical of the Montana uplands. All the round timber used in the mine is cut from the fire-killed trees on the neighboring mountain slopes. For about 5 months of the year good weather prevails, but the balance of the year is changeable and the winters are unusually severe.

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[2] Associate mining engineer, U. S. Bureau of Mines.

Electric power is purchased from the Montana Power Co. The hydroelectric plants of the power company are on the Missouri River a short distance from Great Falls. Electricity is transmitted to the mine at 23,000 volts; for use in the mine and mill, it is stepped down to 440 volts for motors above 5 horsepower, 220 volts for motors under 5 horsepower, and 110 volts for the plant-lighting circuit.

The mine employs a crew of about 225 men and produces an average of 320 tons of lead-zinc-silver ore per day.

The ore is concentrated locally in the company-owned mill which has a capacity of 400 tons per day. Two classes of concentrates are produced: Lead concentrates, which are shipped to the American Smelting and Refining Co.'s plant at East Helena, Mont.; and zinc concentrates, which are treated at the Anaconda electrolytic zinc plant at Great Falls.

HISTORY

The Barker district was discovered in the late fifties soon after the first settlements of the State were established. In 1879 and 1880 large amounts of lead-silver ore were found, and a smelter was erected locally to treat the product of the mines. The exhaustion of the rich ore bodies near the surface ended the first period of the district's history.

A railroad from the district to Great Falls was completed in 1891. The ores were then sent to that city for reduction, until in 1902 the tracks were torn up and the line was abandoned between Monarch, the junction point, and the district. From 1891 to 1927 the mines were worked with varying degrees of success, principally by lessees. The district had several revivals of activity for short periods only to lapse into periods of total inactivity. The interval between 1891 and 1927 comprised the second period in the history of the district.

The third period began when the present company acquired control of the principal mines of the district in 1927. The Barker and Wright-Edwards mines were reopened, and an all-flotation mill was erected. Since the completion of the mill in November, 1928, production has been continuous.

GEOLOGY AND PHYSICAL CHARACTERISTICS OF THE ORE

The Barker and Wright-Edwards mines are both on the principal fissure vein of the district and are now worked as a unit, called the Block P mine. The ore deposit occurs in a large syenite chimney or stock cut by rhyolite dikes. The vein is crescent-shaped in plan and as exposed underground has a total length of about 4,000 feet. The dip of the vein varies from 65 to 88°. The ore varies from 1 to 4 feet in width, although for operating reasons an average width of 5 feet is mined.

The ore minerals are galena, pyrite, sphalerite, and marmatite (ferriferous sphalerite). The gangue consists principally of altered syenite and rhyolite, with subordinate amounts of calcite, barite, marcasite, quartz, and rhodocrosite. The mineralization is characteristically banded, and is distributed as lenses throughout the vein. The walls of the vein are usually well defined.

The ore is of such character that about 95 per cent, as broken by primary blasting in the stopes, will pass through an 8-inch grizzly. The walls stand well for the short time they are required to remain unsupported, except that stulls are needed in rhyolite to support blocky ground.

EXPLORATION

In the early days the vein now being worked was prospected by test pits. As the workings were extended, the vein was explored by driving adits along the vein at depth, and by sinking vertical shafts with crosscuts from the shafts to the vein. Two vertical shafts have been sunk on the property. The mine is worked through the Barker shaft which is the deeper of the two.

Exploration with diamond drills or other deep-hole drilling equipment has never been used in the district......

SAMPLING

The ore minerals are easily recognized so that visual inspection of the working faces, supplemented by regular assay samples, is relied upon for determining the grade of the ore. For geological reference purposes the drifts and raises where development work is progressing in the vein are sampled each week by taking cuts across the faces with a hand pick. In taking these samples, structural irregularities of the vein are disregarded.

Due to the irregular occurrence of the ore in lenses and the variation in width of the mineralization no estimates of ore reserves are made.

DEVELOPMENT

A small amount of mining is being done on the old upper levels of the mine. Access to these workings is by means of an adit. Entry to the deeper portion of the mine, from which most of the ore is mined, is by a two-compartment vertical shaft, 1,200 feet deep. The first 350 feet of the shaft was sunk on the vein, the next 300 feet in the hanging wall, and the balance of 550 feet in the footwall. From the collar to the 400-foot level the level interval is 100 feet, and below that, 200 feet.

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Shaft

The main shaft hoisting compartment is 4 feet 2 inches by 4 feet, and the pipe and manway compartment 3 feet 6 inches by 4 feet. The details of the shaft set framing are shown in Figure 1. The end and wall plates are 8 by 10 inch Douglas fir. Guides are 4 by 4 inches and are secured to the end plates and dividers by lag screws. Posts are of 8 by 8 inch timber. Shaft sets are placed on 5-foot centers and are lagged with 6-inch diameter semi-round lagging with the rounded portion toward the walls. For suspending the wall plates, hanging rods of $\frac{3}{4}$-inch diameter iron, made in two sections, are employed. The unthreaded ends of the rods are bent into hooks for convenience in joining the rods.

Shaft sinking progresses while ore is being hoisted. A heavy timber bulkhead is installed below the ore pocket of the lowest working level to protect the workmen in the bottom of the shaft from falling material. An auxiliary air hoist is used in sinking with a round bucket having a capacity of 750 pounds of rock. During sinking operations the hoist is located on the bottom station of the shaft. The bucket is used in the manway compartment.

Shaft-sinking is done on contract. The routine of operations is about as follows:

1st shift (2 men) ...... Drill and blast.
2nd shift do ...... Place and block timber.
3rd shift do ...... Shovel broken rock.

The rate of advance is about 5 feet per day.

The shaft round used is shown in Figure 2. With this type of round the broken rock is thrown to one end of the shaft for convenience in shoveling, which also allows the water to drain to the other end of the shaft. About 174 cartridges, or 63 pounds, of 1-1/8 by 6 inch, 40 per cent strength special gelatin dynamite are required per round. Electric detonators fired by means of the electric lighting circuit are used in blasting.

Drilling is done with hand-held machines of the jackhammer type using 7/8-inch hollow hexagonal drill steel. Bits are of the double taper of 14 and 5°. The starter steel length is 2 feet with a bit gage of 1-7/8 inches. The bit gage decreases 1/8 of an inch for each 14-inch change in steel length.

Drifts and Crosscuts

Drifts and crosscuts are 6 feet wide and 8 feet high and are timbered with the drift set shown in Figure 3. Drift sets do not ordinarily require lagging at the sides, as the ground is sufficiently firm to stand without it. Sets are round timber; posts are 6 feet 8 inches long and caps 4 feet 8 inches long. Girts are placed at the bottom and at the top of the posts. The batter on the posts when placed in position is 1 to 12. The lagging over the caps consists of 3 to 5 inch diameter lodge-pole pine cut in 5-foot lengths.

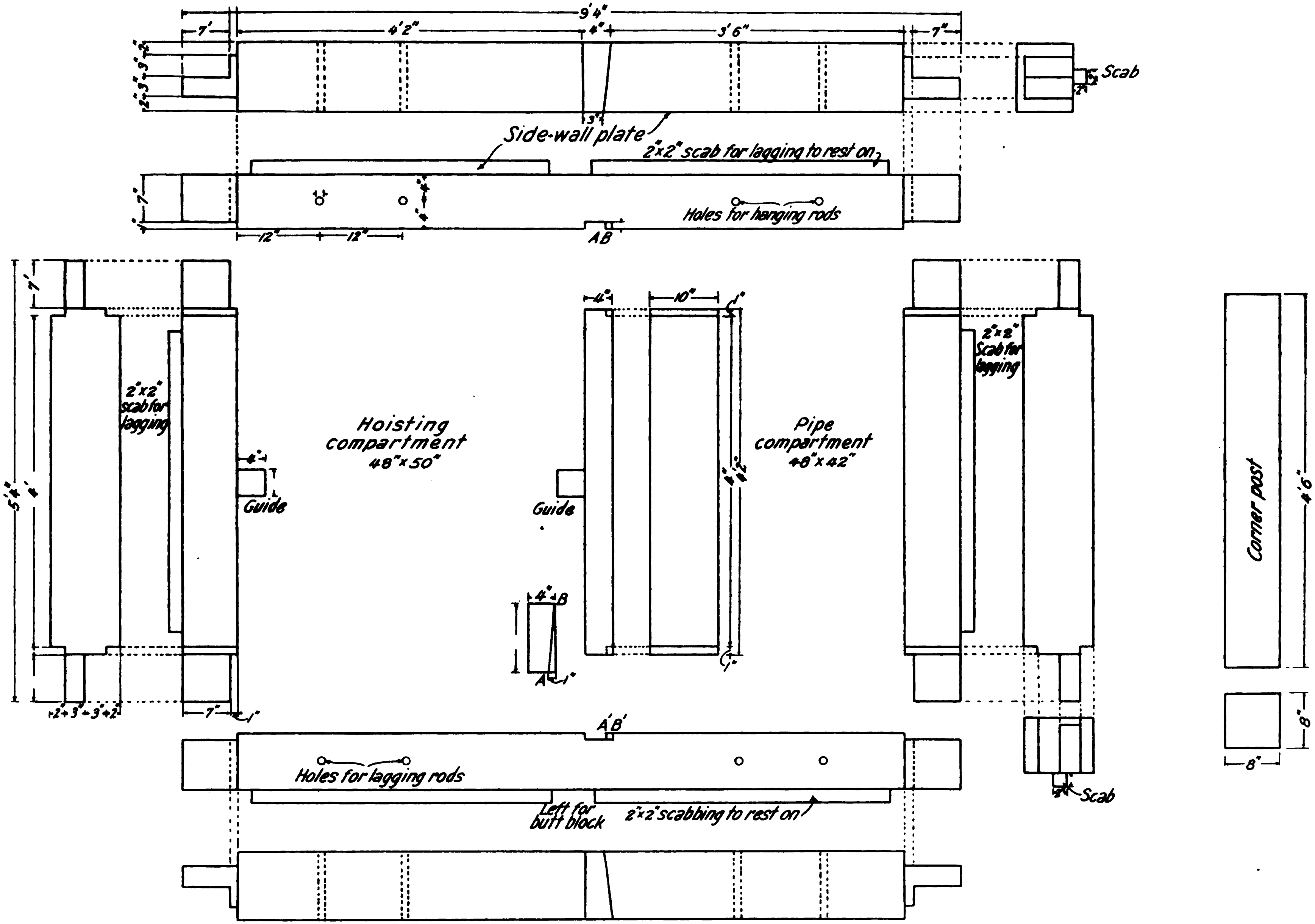

Figure 1.- Plan and side views, two-compartment shaft set

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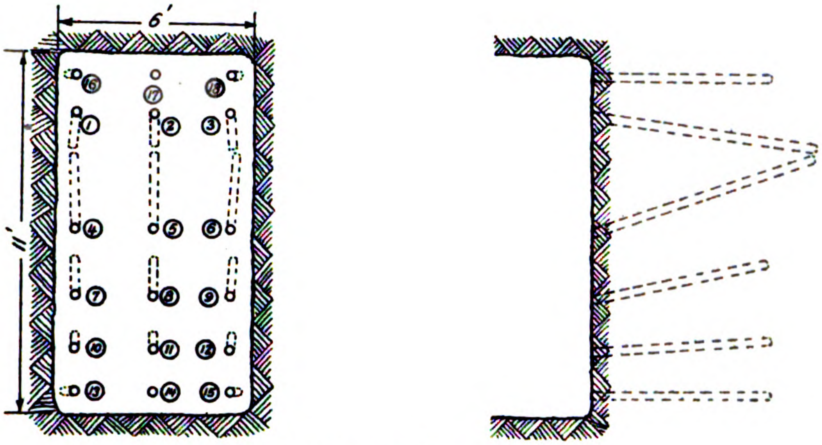


Order of firing shaft round

First	① to ⑥	Incl.	7 ft. deep	11 sticks	40 % gelatin		
Second	⑦ ⑧	⑨	5½ ..	..	9	..	..
Third	⑩ ⑪	⑫	5½ ..	..	9	..	..
Fourth	⑬ ⑭	⑮	5½ ..	..	9	..	..
Fifth	⑯ ⑰	⑱	5½ ..	..	9	..	..

Figure 2.-Standard shaft round

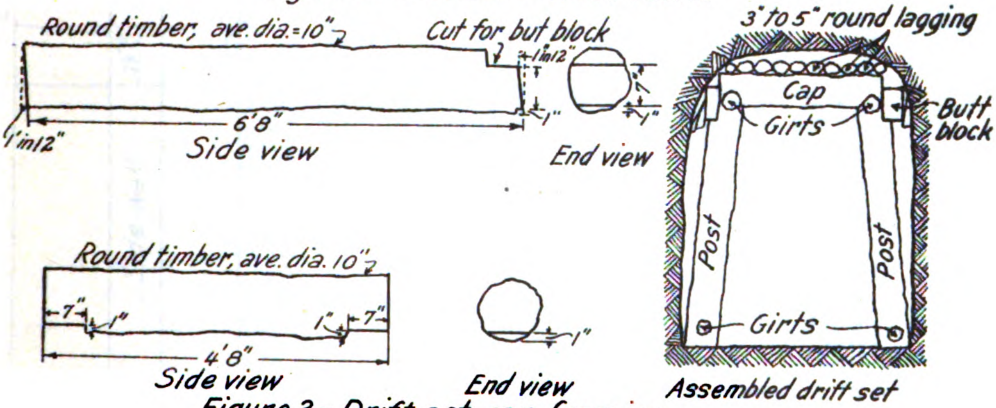
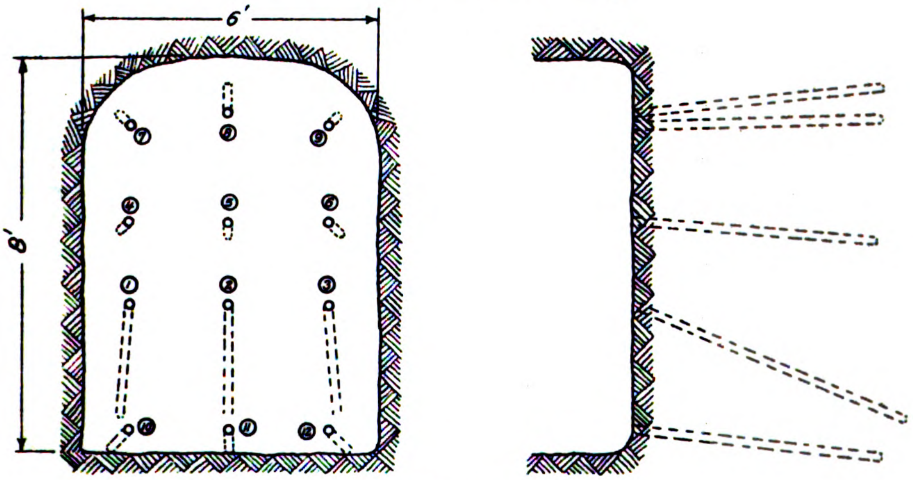


Figure 3.- Drift-set cap framing



Order of firing drift round

First	①	②	③	6 ft. deep	8 to 9 sticks	40 % gelatin		
Second	④	⑤	⑥	5 ..	..	6	..	..
Third	⑦	⑧	⑨	5 ..	..	6	..	..
Fourth	⑩	⑪	⑫	5 ..	..	10	..	..

Figure 4.-Standard drift round for ordinary ground. Additional breast holes are used in hard ground. Upper cuts are used in very wet ground

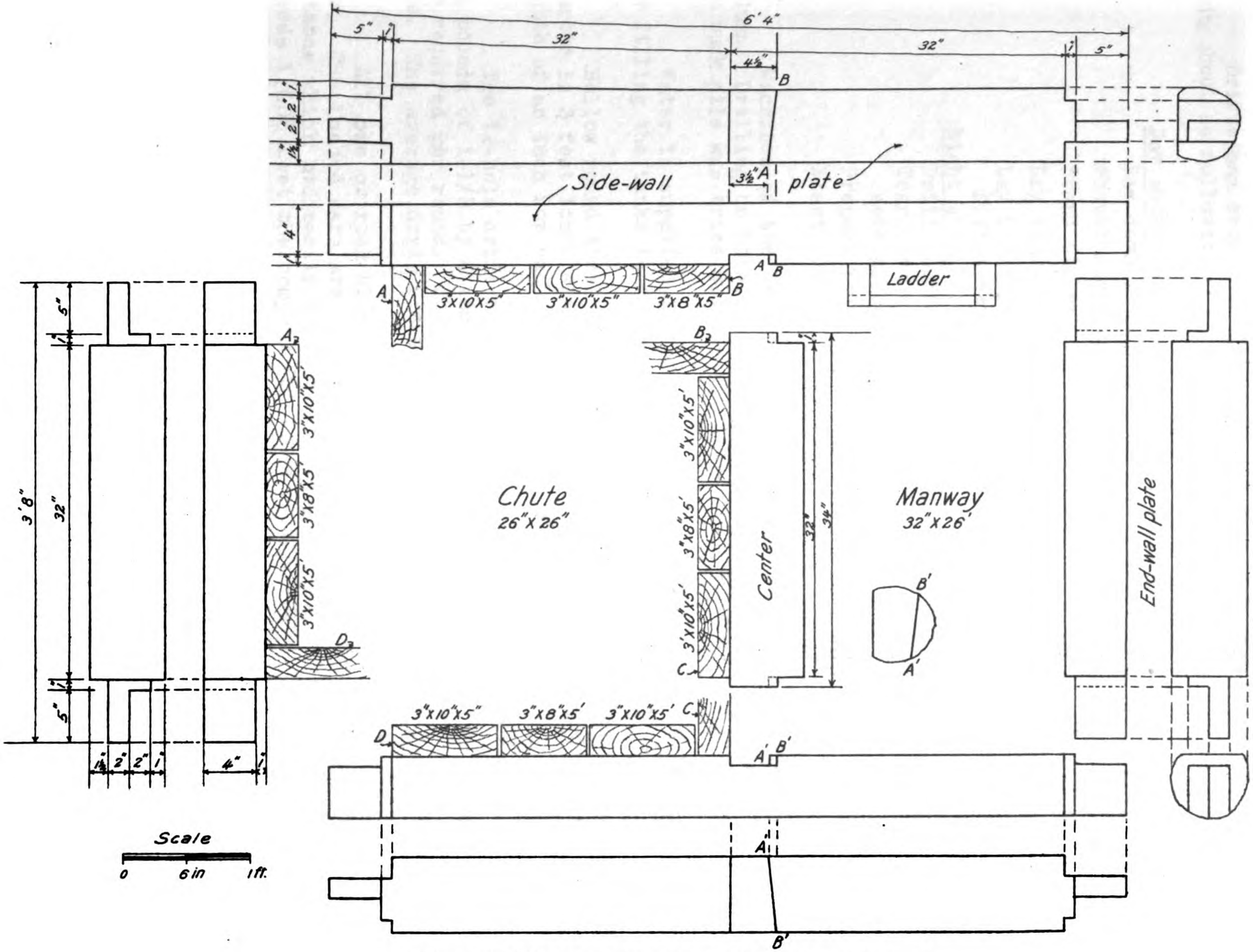


Figure 5.- Plan and side views of regular raise set

Drifts and crosscuts are driven on contract, the cycle of operations being about as follows:

	Hours
Day shift (2 men):	
Bar down	$\frac{1}{4}$
Shovel and tram	$4\frac{1}{2}$
Stand timber	$1\frac{1}{2}$
Lay track (if necessary)	$\frac{1}{2}$
Lay blasting floor, set up machine, fill water tank	$\frac{1}{2}$
Night shift (1 man):	
Drill round	6
Tear down equipment and remove to safe place	$\frac{1}{4}$
Prepare primers and load holes ...	$\frac{3}{4}$
Blast	$\frac{1}{4}$

Machines of the Leyner type are used mounted on an arm attached to a column. Drilling on both shifts with the machine mounted on a crossbar above the muck pile was tried but did not prove satisfactory.

Water is supplied to the machines from water-pressure tanks. The water for filling the tanks is collected underground from drainage crevices.

Hollow round steel $1\frac{1}{4}$ inch is used with the 14 and 5° tapered bit. The starter is 3 feet long, with a bit gage of 2 inches. The gage decreases one-eighth of an inch for each increase of 18 inches in steel length.

The 12-hole drift round is shown in Figure 4. Ninety-three sticks or $33\frac{1}{2}$ pounds of 1-1/8 by 6 inch, 40 per cent strength special gelatin dynamite are required per round. Rounds are fired with No. 6 detonators and triple-tape fuse. The average depth broken per round is $4\frac{1}{2}$ feet.

All ore or rock blasted in driving a drift or crosscut is shoveled by hand. The loaded cars are trammed by hand to the nearest gathering switch, a distance which ordinarily does not exceed 1,000 feet. If the tramming distance exceeds 1,000 feet the company furnishes an additional trammer who does not participate in the earnings of the contract.

Raises

Raises are driven with two compartments, the chute being 2 feet 2 inches by 2 feet 2 inches, and the manway side 2 feet 8 inches by 2 feet 2 inches. The raise set framing details, which are essentially the same as the framing details for the shaft sets, are shown in Figure 5. The style of raise timbering has been found to be advantageous in following the vein, which varies in dip. Where the change in dip of the vein is moderate the posts are set directly on the horns of the plates without beveling the ends. In case of excessive variation the ends of the posts may be beveled or shortened by the timber crew to fit the change in dip of the vein. Sets are spaced on 5-foot centers. All raise timbers are round; the main members of the sets are from 8 to 12 inches in diameter slabbed on the inner side of the raise for convenience in nailing the chute plank lining. Posts for the sets are 4 feet 6 inches long and from 4 to 6 inches in diameter. The chute lining consists of 3-inch plank 8 and 10 inches wide cut in 5-foot lengths. The outside of the riase is lagged on all sides with 4-inch diameter lagging cut in 5-foot lengths. Ladders for the manway compartment are made in 5-foot lengths. The sides of the ladders are of 2 by 4 inch and the rungs of 1 by 4 inch lumber.

All the main raises are driven on contract.

The routine of operations in advancing a raise is about as follows:

	Hours
One shift (2 men):	
Clean off bulkhead and bar down	½
Place sheave and hoist timber	½
Stand timbers	1½
Prepare for drilling	¼
Drill round	3½
Remove drilling equipment ..	¼
Prepare primers and load holes	¾
Blast	¼

Machines of the hand-rotated stoper type are used for drilling. Drill steel consists of 1-inch cruciform heavy ribbed section steel. The steel lengths and bit gages are the same as the jackhammer steel.

The 12-hole raise round used for the average ground encountered is shown in Figure 7. In blasting a round eighty-seven 1-1/8 by 6 inch cartridges, or 31.5 pounds, of 40 per cent strength special gelatin dynamite are required. Rounds are fired with No. 6 detonators and triple-tape fuse. The average progress for each round blasted is about 5 feet.

Timbers and drilling equipment are hoisted to the top of the raise by means of an air tugger hoist. The sheave wheel is chained to a stull placed temporarily in the untimbered portion of the raise above the bulkhead. The rope for hoisting passes up the manway side of the raise over the sheave wheel and down the chute compartment. The plank lining of the chute affords an excellent slide for hoisting supplies. While the raise is being driven the chute side is kept empty of broken rock or ore.

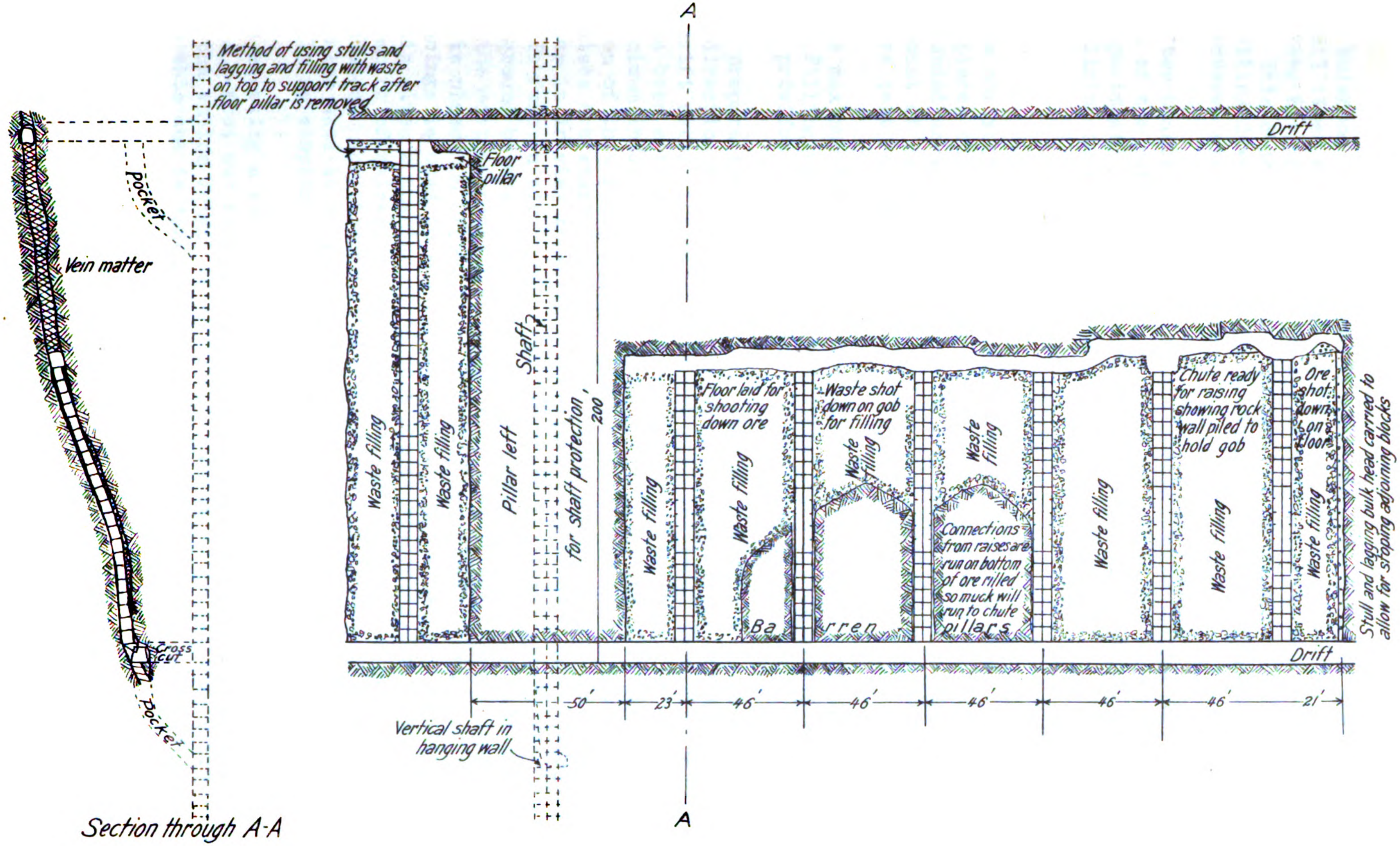

Method of using stulls and lagging and filling with waste on top to support track after floor pillar is removed
Pocket
Vein matter
Cross cut
Pocket
Section through A-A
A
Drift
Floor pillar
Waste filling
Waste filling
Pillar left
Shaft
for shaft protection, 200'
Waste filling
Floor laid for shooting down ore
Waste filling
Waste shot down on gob for filling
Waste filling
Waste filling
Connections from raises are run on bottom of ore milled so muck will run to chute
Barren pillars
Waste filling
Chute ready for raising showing rock wall piled to hold gob
Waste filling
Ore shot down on floor
Waste filling
Stull and lagging bulk head carried to allow for stoping adjoining blocks
Drift
50'
23'
46'
46'
46'
46'
46'
21'
Vertical shaft in hanging wall
A

Figure 6.-Longitudinal and cross section of typical cut-and-fill stope

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A bulkhead of 3-inch plank is maintained over the manway side of the raise at all times when the raise is being advanced. A wooden door, 2 feet 6 inches long by 1 foot in width, made of 3-inch plank, is provided in the bulkhead. This door is secured to the top set by a piece of chain to prevent it from falling down the raise. While drilling or timbering in the raise, the chute is covered with 3-inch plank.

After blasting, when the broken rock prevents opening the door, access to the top of the raise is gained by removing a plank in the chute side of the manway compartment. To provide a footing in the chute, wedges are nailed to the plank lining on the footwall side of the raise.

STOPING

The horizontal cut-and-fill method of mining is used. The vein is so narrow in places that waste must be broken to allow room for working, and moreover the banded arrangement of ore with intervening bands of waste necessitates a large amount of hand-sorting and selective mining in order to maintain the grade of ore sent to the mill.

The maximum length of a stope is 750 feet and the average length about 400 feet. Filling with waste is an integral part of the mining system, as the waste fill provides the working floor of the stope (see fig. 6).

In preparation for stoping operations, drifts are driven along the vein in either direction from the shaft station and the drifts are timbered with the standard drift sets. A raise to connect with the level above is started when a drift has been extended a sufficient distance from the shaft so that there will be minimum interference with further drifting when the raise is being cut. The location of this first through raise is 690 feet from the shaft. Other through raises are started at each additional 690 feet from this first riase. The purposes in driving these through raises in advance of stoping operations are: (1) To furnish air courses for improving the ventilation, and (2) to explore the ground between the two levels so that stoping operations can be conducted in the most economical manner. Beginning at the shaft, every ninth drift set is placed on 6-foot instead of the usual 5-foot centers; each of the 6-foot spacings is used to accommodate a chute and a manway for stoping operations. This gives a spacing of 46 feet center-to-center for stope raises. The 46-foot spacing of raises provides the maximum distance for efficient shoveling into the chutes. The through raises which are cut at every fifteenth stope raise are also used to serve the stopes. The stope raises are carried up periodically as stoping progresses.

In starting a stope the lagging over the back of the drift sets is removed and a 5-foot cut from the back of the drift is blasted onto the drift floor for the entire length of the stope section. The drift sets are left in place when this cut is taken. The ore thus blasted is shoveled into the cars by hand. At the 46-foot intervals a chute and manway raise is started using the standard raise timber sets. After the cut over the back of the drift has been taken, the lagging over the sets are replaced, the chutes installed, and stoping operations are started. The chute lips are made of 3-inch plank with 3-inch wooden gates sliding in wooden cleats.

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The stope is advanced upwards horizontally as a single face for the entire length of the stope section. Selective blasting and hand-sorting are practiced to a great extent to obtain a high-grade product and to minimize loss of ore in the waste. The amount of waste thus produced is more than sufficient to fill the stope. In separating the ore from the waste, three methods are employed, depending on the occurrence of the ore in the vein.

1. Where the ore and waste occur in alternate bands across the width of the vein, they are blasted together and the waste is sorted by hand.

2. Where the ore occurs as a single strong band in the vein the waste is first blasted and then the ore.

3. Where the ore is weak and in a single band the ore is first blasted and then the waste.

Before blasting the ore a floor is laid over the fill to prevent admixture of the ore with the waste. This floor consists of 3-inch plank 8 and 10 inches wide and 5 feet in length. A large part of the plank used for blasting floors in the stope is salvaged from old chutes on the upper levels of the mine. The ore is shoveled into the chutes by hand. With the spacing of the chutes on 46-foot centers the maximum throw for the shovelers does not exceed 20 feet. The waste sorted out from the ore is thrown to one side of the stope to be used for fill. The fill is leveled by hand.

All stoping is done on company account. Usually two men constitute a stope crew - a miner, and a shoveler who also does the sorting. The miner drills the first day on one side of a raise and the following day on the other. In this way there is no interference between ore-breaking and shoveling operations, as the miner is always working on the side of a raise opposite the shoveler. The miner, using a hand-rotated stoper, drills about 15 holes per shift. The holes are inclined slightly so that the ore is thrown toward the raise to reduce the shoveling distance. The tops of the raises are covered with 3-inch plank before blasting.

Rounds are fired with No. 6 detonators and triple-tape fuse. Special gelatin dynamite of 30 per cent strength, in 1-1/8 by 6-inch cartridges, is used.

Steel for drilling is hoisted into the stopes through the chute side of the raises. Hoisting of steel is done in the high stopes with small air tugger hoists and in the low stopes by hand. The dull steel is dropped through a wooden launder constructed of 1 by 4 inch lumber in the manway side of the raise.

Stopes are carried through to the level above. About 5 feet below the level, stulls are placed on 5-foot centers and round lagging is laid thereon. Waste is run onto the lagging for supporting the track on the level. If the walls are hard and firm no additional support is necessary. If the walls are weak and soft, stulls are placed under the drift sets before the floor pillar below the level is removed.

At the end of a stope section the fill is lagged off from the unbroken ore by a vertical row of stulls placed on 5-foot centers. Pole lagging 3 to 5 inches in diameter is nailed to the stulls which are placed from time to time as the stope is advanced.

Where a horse of waste occurs in the vein (see fig. 6) the ore-pass raises are driven through the waste until the bottom of the ore is reached. At the bottom of the ore, inclined drifts are run from two consecutive raises so as to connect with each other. This operation is called rilling. If the bottom of the ore is flat the inclined drifts or rills are started low enough to intersect the ore at the desired point. After the connection is made between the rills the back of the stope is brought back to the horizontal by alternate breaking of ore and filling with waste.

Rock walls are built around the tops of the raises to a height of 4 feet. These walls are built of large slabs of waste and are far enough back from the top of the raise to permit standing room and for placing the next set with the necessary lagging. The rock walls allow the stope floor to be raised to the height of one set without timbering the raise, so that ore may be shoveled directly into the top of the raise without the necessity of shoveling over a 5-foot set of timbers. After the wall reaches a height of 4 feet a set of raise timbers is placed and lagged and the space between the rock wall and timber is filled with waste. The top set is thus always protected from blasting.

The manway side of the raise is kept covered at all times. The chute opening is partly covered so that the hole over the chute is about 24 by 10 inches. The hole is so small that the danger of a man falling down the chute is almost negligible. No accident of this kind has ever occurred in the mine. No grizzlies are used over the chutes.

The chute and manway raises are built up periodically by timbering crews consisting of one timberman and a helper. The timber crews also repair the raises. Single compartment chutes without the adjoining manway were formerly tried but were unsatisfactory. With the single chute, repairing was difficult. Moreover, the ore in places is sticky and has a tendency to pack and hang up in the chutes. If the ore chute became blocked at some distance from the level it was difficult and dangerous to start the ore running. In the present practice of carrying up a manway adjacent to each chute it is a simple matter to free a chute when it is hung up by going up the manway and pounding on the side of the chute or by removing a plank at the side and starting the ore with a bar. Due to the tendency of the ore to stick and set in the chutes the chutes are kept well drawn rather than full or nearly full.

With hand-shoveling, only a small amount of material passes through the chutes at a time so that it is not necessary to break the fall of the ore, as the length of the chutes increases with the height of the stopes. Ordinarily the variations in the dip of the raises afford sufficient checks to break the fall of the ore while traveling through the chutes so that wear on the lining or timbers is not excessive. The faster wear comes at the places where the slope of the chute changes. Straight chutes show less wear.

The advantages of the cut-and-fill method of mining as practiced at Hughesville are: (1) a complete extraction of the ore is made, (2) only a small amount of timber is required, (3) ore is not held in the stopes for long periods, (4) the decreased use of timber and the use of waste for filling reduces traffic in the shaft, (5) a high-grade product is obtained by careful sorting of the ore by hand, (6) excellent ventilation is obtained, (7) the method affords safe working conditions, and (8) the fire hazard is small.

UNDERGROUND TRANSPORTATION

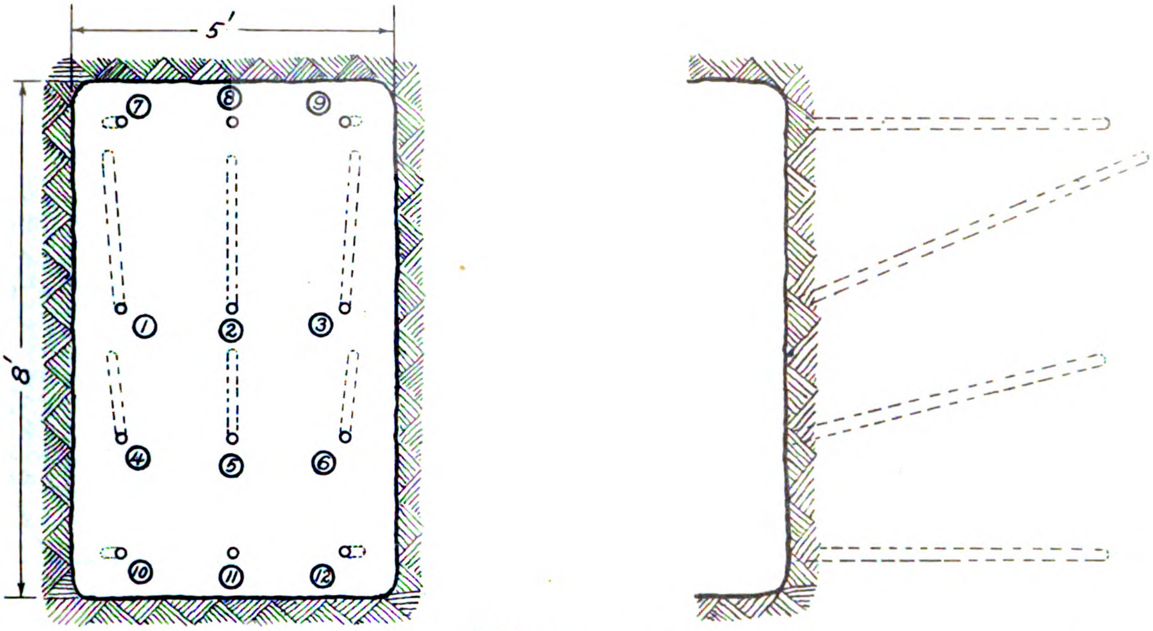
Ore is transported underground in cars having a capacity of about 1,600 pounds of ore each. These cars are of the flat-bottomed side-dump type and are equipped with chilled cast-iron wheels and self-oiling axles. Each axle is in two sections with a continuous sleeve enclosing the whole axle. Wheels are pressed on the axles by a hydraulic press.

Small storage-battery locomotives are used underground. The draw-bar pull of the locomotives is 600 lbs. each at a speed of 3½ miles per hour. The average train consists of 10 one-ton cars. The maximum tramming distance with the locomotives is about 3,000 feet. An extra set of batteries and in some cases two extra sets are supplied for each locomotive so that one set can be charged while the locomotive is in use. The motor-generator set for charging the batteries is located on the surface and the direct current is taken underground to the charging stations.

All track underground consists of 12-pound rails, laid to a gage of 18 inches and an average grade of 0.5 per cent. Ties are 4 by 6 inch timbers 30 inches long spaced on about 30-inch centers. All switches used underground are made locally by the company blacksmiths.

A train crew consists of one motorman and one helper. The helper loads the cars at the chutes and dumps them at the station pocket.

The ore is dumped into the shaft skip-pockets located at each level (see fig. 8) over grizzlies made of old 12-pound rail. The grizzlies have 8-inch openings. The shaft pocket is divided into two compartments, one for waste and the other for ore, by a row of stulls spaced on 5-foot centers. The stulls are lined on both sides with 3-inch plank. To control the flow of ore or waste into the skip measuring pockets, quadrant bin-gates are installed. The quadrant bin-gate details are shown in Figure 9.



Order of firing raise rounds

First	①	②	③	6 ft. deep	8 sticks	40%	gelatin	
Second	④	⑤	⑥	5 "	7 "	"	"	
Third	⑦ to ⑫ Incl.			5 "	7 "	"	"	

Figure 7, - Standard raise round for ordinary ground. In hard ground an extra row of holes is used

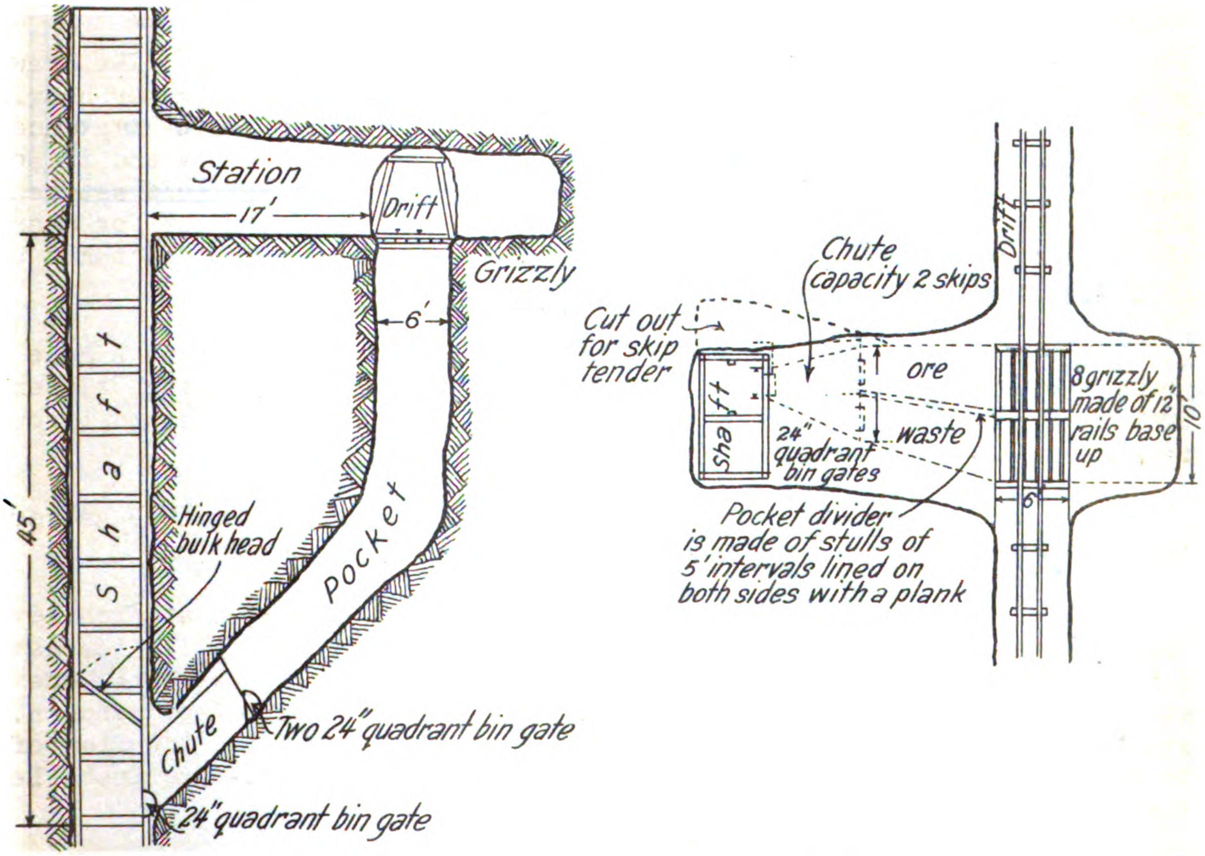


Figure 8 - Plan and section of skip pocket

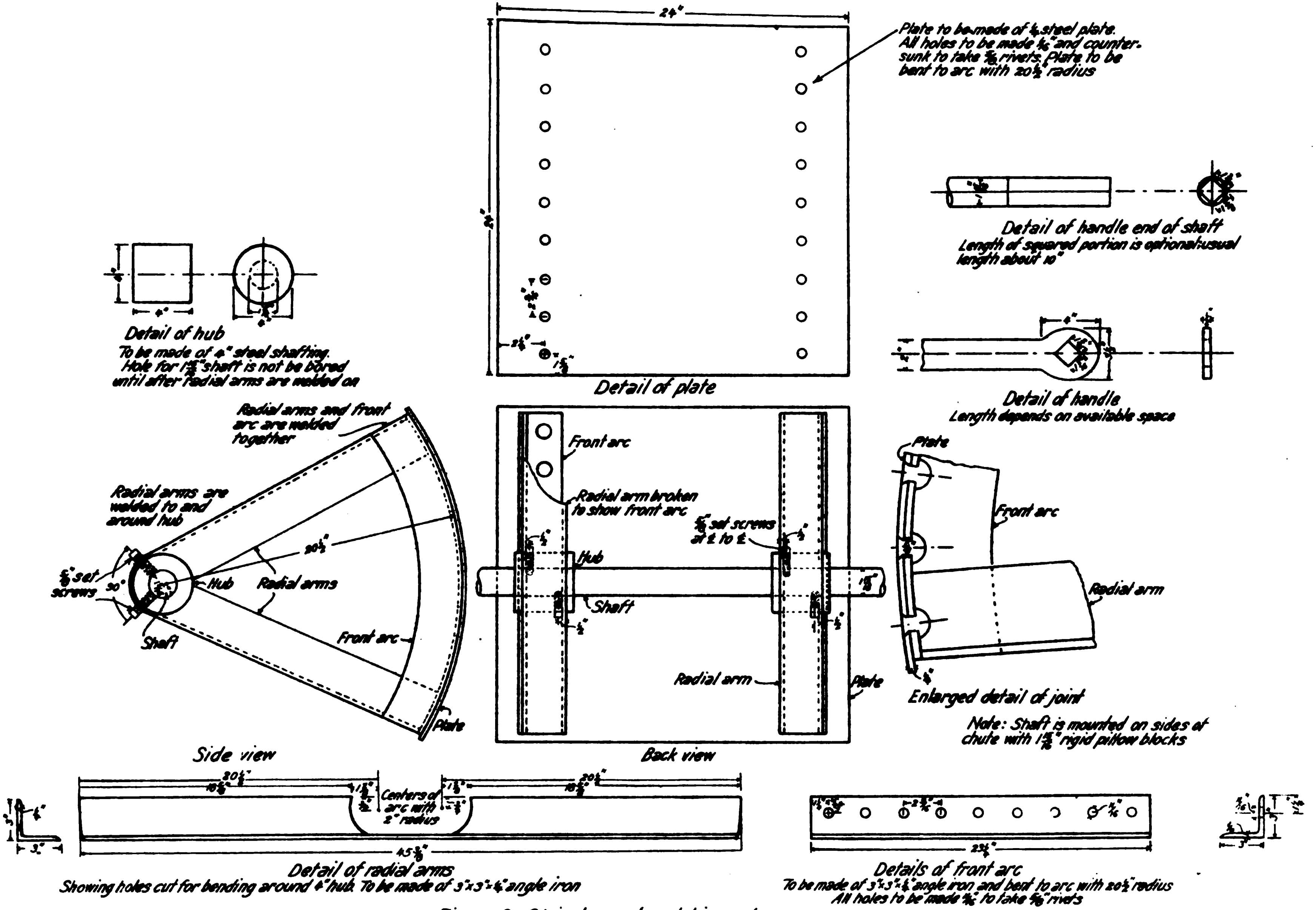

24"
Plate to be made of ¼" steel plate. All holes to be made ⅝" and countersunk to take ⅝" rivets. Plate to be bent to arc with 20½" radius
Detail of plate
Detail of handle end of shaft
Length of squared portion is optional; usual length about 10"
Detail of hub
To be made of 4" steel shafting. Hole for 1⅞" shaft is not be bored until after radial arms are welded on
4"
Detail of handle
Length depends on available space
Radial arms and front arc are welded together
Radial arms are welded to and around hub
⅝" set screws
90°
Hub
Radial arms
20½"
Shaft
Front arc
Plate
Side view
Front arc
Radial arm broken to show front arc
⅝" set screws at ℄ to ℄
Hub
Shaft
1⅞"
Radial arm
Plate
Back view
Plate
Front arc
Radial arm
Enlarged detail of joint
Note: Shaft is mounted on sides of chute with 1⅞" rigid pillow blocks
20½"
Centers of arc with 2" radius
45⅝"
3"
Detail of radial arms
Showing holes cut for bending around 4" hub. To be made of 3"×3"×¼" angle iron
23½"
Details of front arc
To be made of 3"×3"×¼" angle iron and bent to arc with 20½" radius
All holes to be made ⅝" to take ⅝" rivets

Figure 9.- 24-inch quadrant bin gate

Original from THE OHIO STATE UNIVERSITY

Ore is hoisted to the surface in a skip having an actual capacity of 3 tons of ore. The dimensions of the skip are 3 feet 2 inches by 3 feet 4 inches in cross-section and a length of 6 feet.

To catch the spillage from the skip when loading, an inclined bulkhead is placed in the shaft, which diverts the ore into the skip-pocket chute at the lowest level. The bulkhead is made of 3-ply 1-inch lumber covered with $\frac{1}{4}$-inch sheet iron. The lower end of the bulkhead is hinged to the wall plate. When loading the skip at the lowest pocket the bulkhead is raised vertically against the wall plates by means of a hand windlass and is fastened.

The hoist is of the single-gear reduction type with a single drum 4 feet 6 inches in diameter and 3 feet 4 inches wide. The hoist is equipped with overspeed and overwind controls. The hoisting cable is 1-inch diameter, plow steel, 6 strand 19 wires, with hemp core. The hoisting speed is 600 feet per minute.

Workmen are transported through the shaft on a double-deck cage, each deck holding six men. When men are to be lowered or hoisted the skip is detached from the cable and run on an I-beam crawl. The decks of the cage are run over the iron sheets at the collar of the shaft onto a heavy door that drops over the shaft and are then fastened to the hoisting cable or to the other deck. The decks of the cage are equipped with small wheels for moving over the iron sheets. The change from skip to cage is made in about 6 minutes.

AERIAL TRAMWAY

The mill is situated about 400 feet below the elevation of the mine and 2 miles distant. To transport the ore from the mine to the mill an aerial tramway with a stationary track cable is used. The distance between the tramway terminals is 10,250 feet. The buckets on the tramway have a capacity of 1,150 pounds of ore each. There are 56 buckets on the line spaced at intervals of 367 feet. One round trip of the buckets is equal to an average of 32$\frac{1}{2}$ tons. The cable carrier for the loaded side is 1-3/8-inch in diameter and the empty side 1 inch in diameter. Both cables are of the locked coil type. The traction cable is of 6 strands of 7 wires each, Lang lay, and 5/8 inch in diameter. The buckets are attached and detached from the traction rope automatically, although supervision is required for spacing the buckets at appropriate intervals at both the terminals and for loading and dumping the buckets. The traction rope is below the carriers and the bucket grips are of the underhung type.

The grade of the tramway is fairly uniform, with no high ridges to cross, and the cables are run without any change in alignment. Two tension stations are in the line. The tramway towers are of the 4-legged type spaced at intervals of about 330 feet. A crew of 5 men are required to operate the tramway which is run only on one shift. The motor used on the tramway acts principally as a brake; it is of 20 horsepower, uses current of 440 volts, and makes 900 revolutions per minute.

Oil used for heating the mine buildings is transported over the tramway to the mine from storage tanks at the mill in oil drums equipped with special fittings. (See fig. 10.) The drums are emptied by using compressed air to force the oil from the carrier drum to the storage tank located at a higher elevation. Care must be exercised in the amount of compressed air turned into the drums, as on several occasions the heads of the drums have been blown out by the use of excessive air pressure.

At the loading terminal of the tramway the ore bin chute is equipped with a steel plate sliding in a slot in the bottom of the chute lip. The gate is positive in action, as the ore stream is cut off from below and the ore can not choke the return of the gate when the ore stream is cut off. The lowering or raising of the gate is done by a system of levers operated by hand.

WAGE SCALE AND BONUS SYSTEM

For an isolated district the labor supply is plentiful and efficient. In the winter the labor supply is largely drawn from the surrounding ranches. The Block P mine follows the practice of having a varying wage scale proportionate to metal sales prices. The wage scale effective at the mine in March 1930 was as follows:

Blacksmith	$6.50
Hoistman (surface)	6.00
Miner	5.50
Motorman	5.50
Motorman helper	5.00
Nipper	5.00
Pipeman	6.00
Pipeman helper	5.00
Pumpman	6.00
Shift boss	6.25
Shoveler	5.00
Skip-tender	5.50
Timberman	5.50
Timberman helper	5.00
Timber framer	5.50
Timber framer helper	5.00
Tool sharpener	8.00
Tool sharpener helper	5.50
Trammer (hand)	5.00

The shaft, the raises to connect levels for ventilation and exploration purposes, and all the drifts and crosscuts are driven on contract.

The rate for sinking the shaft is $22.50 per linear foot of completed shaft. All explosives and other supplies are furnished by the company.

The raises are contracted for at the rate of $5 per linear foot of completed raise for the first 100 feet and $6 per linear foot for the second 100 feet. Contractors buy the explosives and blasting supplies from the company.

Drifts and crosscuts are contracted for at the rate of $7 per foot of completed drift or crosscut. Contractors do the drilling and blasting, shoveling, timbering, track-laying, and tramming if the tramming distance does not exceed 1,000 feet. A contract crew for a drift or crosscut consists of one miner and two shovelers. The three men share equally in the earnings of the contract. Explosives and other blasting supplies are purchased by the contractors from the company. Drilling and blasting are done on one shift and the shoveling and timbering on the other in practically all headings. Switches are put in by the contractors working on company account.

Shaft stations and sumps are cut on contract at the rate of 15 cents per cubic foot of rock excavated. The contractors furnish the blasting supplies and explosives. The timbering of the shaft stations is done on company account.

The shaft skip pockets are driven at the rate of $7 per linear foot. The company furnishes explosives and blasting supplies.

SAFETY, VENTILATION, AND FIRE HAZARD

The shift bosses and mine foreman are trained in first-aid work. The company employs a resident physician and maintains a four-bed hospital at the mine.

The ventilation is natural and the working conditions underground are excellent the year around.

The fire hazard is small, as all the stopes are filled with waste.

Development work done in 1929

	Linear feet
Crosscuts and drifts	3,120
Raises	970
Stations and sumps	182
Total	4,272

Summary of costs in units of labor, power, and supplies

Block P mine Year, 1929

Tons of dry ore hoisted: 106,242 Mining method: Horizontal and fill.

	Development	Mining	Total
A. Labor (man-hours per ton):			
Breaking (drilling and blasting)	0.116	1.636	1.751
Shoveling	0.120	1.812	1.932
Timbering	0.048	0.508	0.556
Underground haulage	0.045	0.445	0.490
Pumping	-	-	0.096
Hoisting	-	-	0.165
Underground miscellaneous	-	-	0.175
Supervision	-	-	0.185
Total labor underground	-	-	5.350
Average tons per man per shift underground	-	-	1.495
Surface haulage	-	-	0.072
Tool sharpening	-	-	0.082
Timber framing	-	-	0.094
Miscellaneous surface	-	-	0.221
Total labor on surface	-	-	0.469
Average tons per man per shift on surface properly chargeable to underground operations	-	-	17.058

	Development	Mining	Total
B. Power and supplies:			
Explosives (sticks per ton)	0.789	7.089	7.878
(pounds per ton)	0.286	2.568	2.854
Detonators (number per ton)	0.114	1.963	2.077

Power (kw.h. per ton)		17.455
Air compression	9.974	
Hamling	0.676	
Drainage	1.134	
Hoisting	4.886	
Tramway	0.175	
Miscellaneous	0.610	
Total power	17.455	
Timber:- Pole lagging (lin. ft. per ton, 3 to 6 in. diam.)		6.234
Stulls (lin. ft. per ton, 8 to 12 inch diam.)		1.304
Sawed stock (bd. ft. per ton)		3.955
2 by 4-16 ft. long	0.164	
1 by 4-16 ft. long	0.062	
3 by 8-10 ft. long	2.198	
3 by 10-10 ft. long	1.531	
Total	3.955	

C. Labor percentage of total cost	72.63
Power and supplies percentage of total cost	27.37

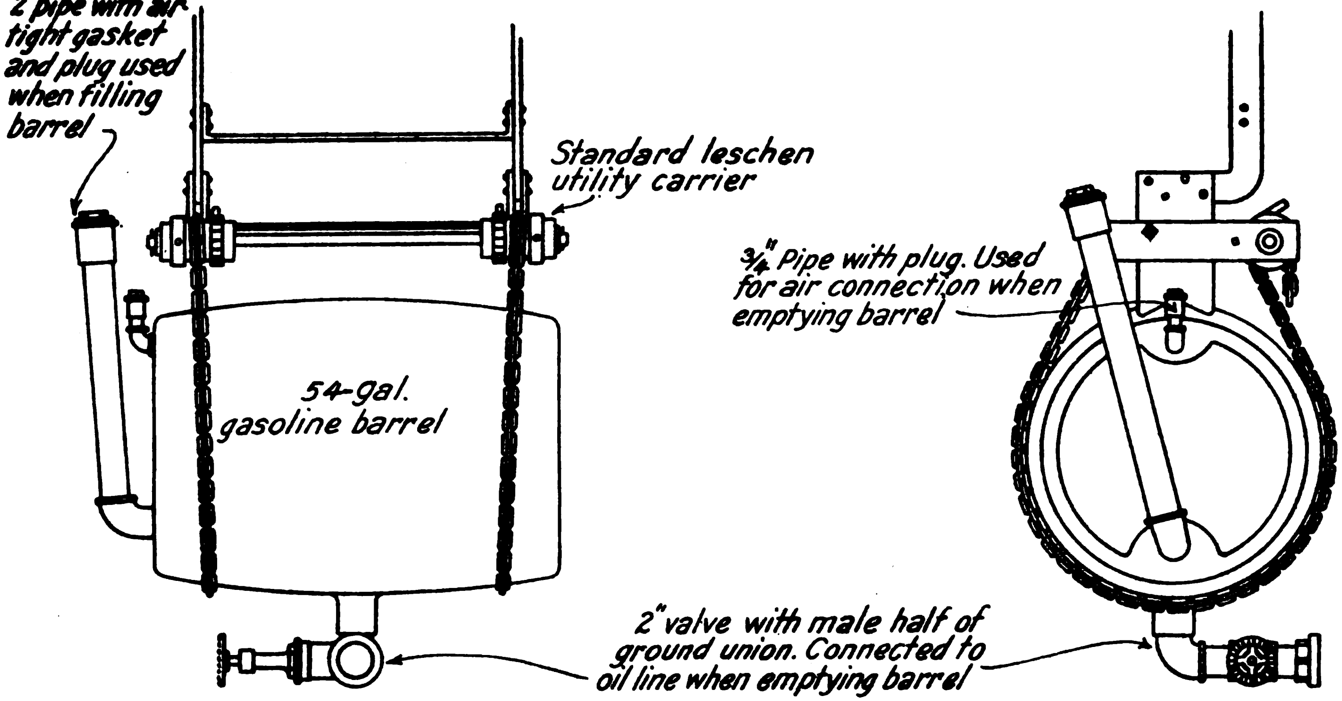

2" pipe with air tight gasket and plug used when filling barrel
Standard leschen utility carrier
54-gal. gasoline barrel
$\frac{3}{4}$" Pipe with plug. Used for air connection when emptying barrel
2" valve with male half of ground union. Connected to oil line when emptying barrel

Figure 10.-Oil carrier for tramway